

## Nutritive Value of Introduced Bamboo Species for Livestock Feed in Ethiopia

<sup>1</sup>F.H. Desalegne, <sup>2</sup>D.Y. Burru, <sup>2</sup>Y.M. Mengesha, <sup>3</sup>A.G. Tegegne and <sup>4</sup>E.G. Zemenfeskidus

<sup>1</sup>Wood Technology Research Center, Ethiopian Environment and Forest Research Institute,  
P.O. Box: 2322, Addis Ababa, Ethiopia

<sup>2</sup>Central Ethiopia Environment and Forest Research Center, Ethiopian Environment and  
Forest Research Institute, P.O. Box: 30708, Addis Ababa, Ethiopia

<sup>3</sup>Bahirdar Environment and Forest Research Center, Ethiopian Environment and  
Forest Research Institute, P.O. Box: 2128, Bahirdar, Ethiopia

<sup>4</sup>Debre Zeit Agricultural Research Center, Ethiopian Institute of Agricultural Research,  
P.O. Box: 32, Debre Zeit, Ethiopia

**Abstract:** This study was aimed to evaluate nutritive values of leaves collected from different introduced bamboo species planted in Chagni and Jimma areas to identify suitable species for multiple bamboo products including livestock feed. The species included *Dendrocalamus hamiltonii*, *Dendrocalamus membranaceus*, *Bambusa vulgaris* and *Guadua amplexifolia*. Parameters tested were Moisture Content (MC), Ash Content (Ash), Organic Matter (OM), Nitrogen Content (N), Crude Protein (CP), Dry Matter (DM), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Acid Detergent Lignin (ADL), Cellulose and Hemi-cellulose. The result showed highly significant difference ( $p < 0.001$ ) between study sites for N, CP and ADF contents. However, there was no significant difference ( $P < 0.05$ ) among the different bamboo species for most of the tested parameters except for NDF, Cellulose and Hemi-cellulose contents. The study showed that leaves of the introduced bamboo species have good organic matter and crude protein and can be used for animal feed substitution especially in dry seasons where there is a scarcity of fodder.

**Key words:** *Dendrocalamus hamiltonii* • *Dendrocalamus membranaceus* • *Bambusa vulgaris* • *Guadua amplexifolia* • Bamboo leaves • Nutritive value

### INTRODUCTION

Bamboo leaf is an excellent animal fodder as it contains 18-22% protein [1-3]. It has the highest amount of crude protein and good for milk animals during the 305 day lactation period for more milk yield. Fresh bamboo leaf as organic chicken feed results in 70% weight gain as compared to those fed on standard diets. Bamboo leaf is considered excellent for Goats reducing protein need to 14%. Beyond its nutritional values, bamboo leaf can be used for preservation of raw milk under village condition especially during transportation as simple and cost effective technique [4].

Nowadays, livestock population decreased, at least in north western Ethiopia, as compared to the previous

five years, mainly because of feed shortage and prevalence of diseases. Feed shortage, particularly in dry season is the primary problem. This in turn increased the utilization of the two indigenous bamboo species (*Oxytenanthera abyssinica* and *Oldeania alpina*) as animal feed, since it is drought resistant and evergreen plant throughout the dry season providing green forage to ruminants [5]. Reports indicated that bamboo played a primary role in providing forage to livestock especially during the extended dry season. Feeding bamboo to ruminants is a long time tradition in Ethiopia. Thus, bamboo leaf is recommended as an important feed resource which is cheap, easily accessible and with good nutritive value for livestock in the bamboo growing areas of Ethiopia [2, 5].

**Corresponding Author:** D.Y. Burru, Central Ethiopia Environment and Forest Research Center,  
Ethiopian Environment and Forest Research Institute, P.O. Box: 30708,  
Addis Ababa, Ethiopia. Tel: +251911120445.

Besides the two indigenous bamboo species, many bamboo species were introduced in Ethiopia since 2007. Seven of the species from first entries, namely *Denderocalamus asper*, *Denderocalamus hamiltonii*, *Denderocalamus giganteus*, *Denderocalamus membranaceus*, *Bambusa vulgaris* sub. var. *green*, *Bamusa vulgaris* sub. var. *vitata* and *Bambusa balcooa* have been tested for their adaptability, growth performance and biomass yield in different locations of the country. Therefore, this study was conducted to evaluate the nutritional value of these species, grown under on-stations at Chagni and Jimma areas of Ethiopia.

## MATERIALS AND METHODS

**Description of the Study Area:** The Bamboo leaf samples were collected from Chagni and Jimma areas of Ethiopia. Chagni is located in Guangua district, Northwest Ethiopia, with a longitude and latitude of 10° 57' N and 36° 30' E and an elevation of 1583 meters above sea level. The study area has received uni-modal rainfall pattern and gets rain at least nine months with variable intensity. The annual precipitation ranges from 1685 to 1870 mm. The annual mean temperature of the area ranges from 17°C to 22°C [6]. Jimma is found in the Southeast Ethiopia (7° 46' N and 36° 0' E) with an altitude of 1753 meter above sea level. It has an average annual rain fall of 1624 mm and an average temperature of 18.9°C. It is situated in a sub-humid tepid to cool mid-highland agro-ecological zone [7].

**Sample Collection:** Authentic representative bamboo leaf samples were collected from study sites. The study species were *Denderocalamus hamiltonii* (DH), *Denderocalamus membranaceus* (DM), *Bambusa vulgaris* (BV) and *Guadua amplexifolia* (GA). The collected fresh bamboo leaf samples were put in to paper bags, labeled accordingly and safely transported to Addis Ababa, Central Ethiopia Environment and Forest Research Center. The bamboo leaves were placed in to a green house and then spread on thin canvas sheet and dried in open air until all the leaves were dried uniformly. The dried leaves were hand-crushed and further ground using mortar and pestle for about 2 mm size and then powder leaves were put in to the paper bag at room temperature until the analysis was carried out.

### Nutritional Analysis

**Determination of Moisture Content:** Approximately 2 grams of grounded bamboo leaf sample was weighed

and dried at 105°C for 5 hours. Oven dry weight was taken after allowing the samples to cool in a desiccator. The experiment was done in three replications and the result was expressed as a percentage of the weight loss from the original weight [8]

**Determination of Ash:** Approximately 2 grams of powdered bamboo leaf sample was first heated on a burner in air to remove its smoke. Then it was burned in a furnace at 550°C. The ash content was expressed as a percentage ratio of the weight of the ash to the oven dry weight [9].

**Determination of Dry Matter and Organic Matter:** The dry matter (DM) and organic matter (OM) were analyzed according to AOAC procedure [10]. The OM content was calculated as the difference between DM and ash content on DM basis.

**Determination of Total Nitrogen and Crude Protein:** Exactly 0.5 gram of each bamboo leaf sample, in triplicate, was weighed and transferred to Kjeldahl digestion tube plus one Kjeldahl tablet, copper sulfate-potassium sulfate catalyst. Then 10 ml of concentrated, nitrogen free, sulfuric acid was added. The tube was then mounted in the digestion heating system which was previously set to 240°C and capped with an aerated manifold. The solution was then heated at the above temperature until a clear pale yellowish-green color was observed which indicates the completion of the digestion. The tubes were then allowed to cool to room temperature. Their content was quantitatively transferred to Kjeldahl distillation apparatus followed by addition of distilled water and 30 % (w/v) sodium hydroxide. Steam distillation was then started and the released ammonia was absorbed in 25 ml of 2 % boric acid. Back titration of the generated borate was then carried out versus, 0.02 M, hydrochloric acid using methyl red as an indicator. Blank titration was carried in the same way. The percentage of nitrogen content was then calculated [11]. The protein content was calculated using the nitrogen conversion factor of 6.25 as proposed by Greenfield and Southgate [12].

**Determination of Neutral Detergent Fiber, Acid Detergent Fiber, Acid Detergent Lignin, Cellulose and Hemi-Cellulose Contents:** Neutral detergent fiber (NDF) and Acid detergent fiber (ADF) were analyzed by using the procedures of Van Soest et al., Goering and Van Soest and AOAC [10, 13, 14]. Acid detergent lignin (ADL) was determined by subjecting ADF residue to 72% sulfuric

acid. Cellulose and Hemi-cellulose were calculated as the difference between NDF and ADF and ADF and ADL, respectively [15].

**Data Analysis:** Data obtained from the experiment were subjected to Analysis of Variance (ANOVA) using the General Linear Model (GLM) with SAS statistical software version 9.0 and SAS Studio. When significant differences were detected, differences among treatment means were tested using Least Significant Difference (LSD) [9].

## RESULTS AND DISCUSSION

The chemical composition of the experimental bamboo leaves is presented in Table 2. The result showed highly significant difference among the bamboo species in acid detergent fiber content. There was also a significance difference for cellulose and hemi-cellulose between the species. Other tested nutrient compositions showed no difference for the species. The study also showed that there is a high significance difference for nitrogen and crude protein and a significant difference for moisture content, dry mater, neutral detergent fiber and hemi-cellulose contents between different growing locations. Species and location interaction effects had a significant difference for neutral detergent fiber and hemi-cellulose parameters (Table 1).

Maximum mean moisture content was recorded for *Guadua amplexifolia* species (4.92%) and minimum for *Bambusa vulgaris* (4.17%). Moisture content of leaves collected from Jimma and Chagni had 4.92 % and 4.25 %, respectively (Table 2). The low moisture content of the bamboo leaves is an index of the great shelf-life of their meal [16]. When compared to other studies the results are below the value of tropical bamboo leaves reported by Antwi-Boasiako *et al.*, which is from 10.34% to 10.71% [16]. Therefore, the introduced bamboo species may have longer shelf-life. The dry matter content among bamboo species and between growing locations was comparable, although it appeared that leaves of *Bambusa vulgaris* collected from Chagni had superior values (Table 2). Values of DM content under this study are slightly higher than the DM values of other studies done for indigenous bamboo leaves [15, 17].

There was a significant difference in ash content among the bamboo species but not between growing locations (Table 1). The values of ash content for the bamboo leaves range from 9.12% for *Dendrocalamus hamiltonii* to 23.83% for *Bambusa vulgaris*. The result was comparable with previous studies and previous

figures for various bamboo species collected from different parts of the world [15, 16]. The ash content of plants is directly related to the mineral composition of the soil, that is, their growth sites. The content of ash in the bamboo samples suggests their possession of a large deposit of mineral elements.

The organic matter contents of the introduced bamboo species in the present study range from 76.17 to 90.58%. Highest OM value was recorded for *Dendrocalamus membranaceus* grown at Chagni area. The values were higher than those recorded for the indigenous lowland bamboo (*Oxytenanthera abyssinica*) [15, 17]. The leaves of the introduced bamboos had crude protein content ranging from 15.17% (*Guadua amplexifolia*) to 37.92% (*Dendrocalamus hamiltonii*) in dry basis. The value was comparable with the CP content reported for Cassava leaves (24.88%), *T. triangulare* (31.00%), Elephant grass (27.00%) and Niger seed cake which have better CP content for animal feed and better than the indigenous lowland bamboo [15-17]. Crude Protein value of 8% is required to satisfy maintenance requirement of ruminant animals [17]. Therefore, bamboo leaves from the study species can satisfy production requirement for livestock feed. From the study locations, Jimma has got better result with regard to CP. Mekuria *et al.*, also indicated that the inclusion of bamboo leaf hay increased CP content of animal diet and decreased NDF, ADF and ADL contents [17].

There was highly significant difference in ADF content among the bamboo species tested but no significant difference for NDF and ADL values (Table 1). Highest NDF and ADF contents were recorded for *Bambusa vulgaris* (76% and 46% respectively) while lowest NDF and ADF contents were observed in *Guadua amplexifolia* (68%) and *Dendrocalamus membranaceus* (36%) respectively. Feeds with fiber content exceeding 55% expressed low in CP or other essential nutrient contents. Straws are generally characterized by relatively low nutrient content and high fiber content as compared to bamboo leaf hay [15]. NDF concentration of forage is a good predictor of voluntary DM intake by sheep [13]. The results from the study are comparable with previous studies on *Oxytenanthera abyssinica* [15, 17].

Statistically similar Acid Detergent Lignin concentration was recorded for all studied bamboo species. ADL content of the species in descending order is GA (7.33%), DH (7%), DM (6.67%) and BV (6.33%) (Table 2). When compared between the growing location,

Table 1: Analysis of variance for variability in chemical composition of introduced bamboo species collected from Jimma and Chagni areas of Ethiopia

Mean Squares												
Source of variation	DF	MC	Ash	OM	N	CP	DM	ADF	NDF	ADL	HC	Cell
Location	1	2.65*	5.61ns	3.71ns	14.82***	584.40***	2.65*	8.17ns	13.50*	6.00*	0.67ns	48.17*
Species	3	0.578ns	25.28*	418.89ns	0.61ns	24.67ns	0.57ns	41.50***	6.39ns	1.11ns	34.89*	34.83*
Loc*Species	3	0.30ns	23.60*	20.47*	0.19ns	7.49ns	0.30ns	2.83ns	9.5*	0.22ns	12.67ns	28.61*
R <sup>2</sup>		0.79	0.79	0.80	0.85	0.85	0.57	0.84	0.68	0.68	0.72	0.79
CV		11.94	17.85	2.84	11.25	11.4	0.79	4.23	2.34	13.02	8.74	7.41

= (p<0.05); \*\* (p<0.01); \*\*\* (p<0.001); CV: coefficient of variation

MC-Moisture Content, Ash-Ash Content, OM-Organic Matter, N-Nitrogen Content, CP-Crude Protein, DM-Dry Mater, ADF-Acid Detergent Fiber, NDF-Neutral Detergent Fiber, ADL-Acid Detergent Lignin, HC-Hemi-cellulose, Cell-Cellulose

Table 2: Proximate chemical composition of introduced bamboo leaf samples from Jimma and Chagni areas of Ethiopia

Parameter											
Treatment	MC	DM	Ash	OM	N	CP	NDF	ADF	ADL	HC	Cell
Species											
<i>B. vulgaris</i>	4.17b	95.83a	17.02a	82.98b	4.48ab	28ab	72a	42.67a	6.33a	33a	32b
<i>D. hamiltonii</i>	4.58b	95.42ab	14.64ab	85.07ab	4.77ab	29.8ab	71b	43.67a	7.00a	29.3bc	36.35a
<i>D. membranaceus</i>	4.67ab	95.33ab	12.00b	87.94a	4.95a	30.97a	71.67ab	38.67b	6.67ab	27.3c	31.34b
<i>G. amplexifolia</i>	4.92a	95.08b	14.36ab	85.64ab	4.23b	26.35b	69.67b	38.67b	7.33a	31ab	31.34b
Location											
Jimma	4.92a	95.08b	14.99a	85.01a	5.39a	33.71a	70.34b	40.33a	6.33b	30.33a	34.17a
Chagni	4.25b	95.75a	14.02a	85.80a	3.82b	23.84b	71.84a	41.5a	7.33a	30a	31.34b

MC-Moisture Content, Ash-Ash Content, OM-Organic Matter, N-Nitrogen Content, CP-Crude Protein, DM-Dry Mater, ADF-Acid Detergent Fiber, NDF-Neutral Detergent Fiber, ADL-Acid Detergent Lignin, HC-Hemi-cellulose, Cell-Cellulose

Chagni showed significantly higher ADL concentration (7.33%) than Jimma (6.33%). Previous studies by Gebreziabhear and Mekuria *et al.*, also showed comparable results, 8.7 % and 8.3 % respectively [15, 17].

Statistical uniform and highest concentration of Hemi-cellulose was gain from *Bambusa vulgaris* and *Guadua amplexifolia* (33% and 31% respectively). Similarly, statistical uniform and lowest concentration of Hemi-cellulose was recorded for *Dendrocalamus hamiltonii* and *Dendrocalamus membranaceus* (29.3% and 27.3% respectively) (Table 2). No variation was seen among growing locations. The results are in agreement with other reports done for *Oxytenanthera abyssinica* [15, 17]. Significant variations were seen between bamboo species and growing locations for Cellulose (Table 1). Highest Cellulose content was recorded for *Dendrocalamus hamiltonii* (36.35 %) and all the rest bamboo species have statistically similar low Cellulose contents. Among growing sites bamboo grown at Jimma had higher Cellulose content. The results are in consistence with previous studies for indigenous bamboo [15, 17].

## CONCLUSION

The proximate composition of the four introduced bamboo species reveals that their leaves are rich in organic matter and crude protein contents. They have

also lower moisture, neutral detergent fiber and acid detergent fiber contents. Their average protein content is a source of amino-acid while their low moisture content is an index of their great permanence due to less microbial susceptibility and long shelf-life of their meal. Among the bamboo species evaluated, *Dendrocalamus membranaceus* and *Dendrocalamus hamiltonii* had higher crude protein contents. The introduced bamboo species grown in humid areas also had better crude protein content. Lack of fodder in Ethiopia, for longer periods of the year especially at the dry seasons, poses a huge threat to animal feed security, as these will make animals unproductive. Therefore, inclusion of bamboo leaf in animal diet can increase essential nutrients and decrease the fiber content. This would also promote the sustainable utilization of bamboo that contributes to broaden the application of non timber forest products as a fodder source for farm animals in developing countries, especially in areas where it is increasingly difficult to maintain food security.

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